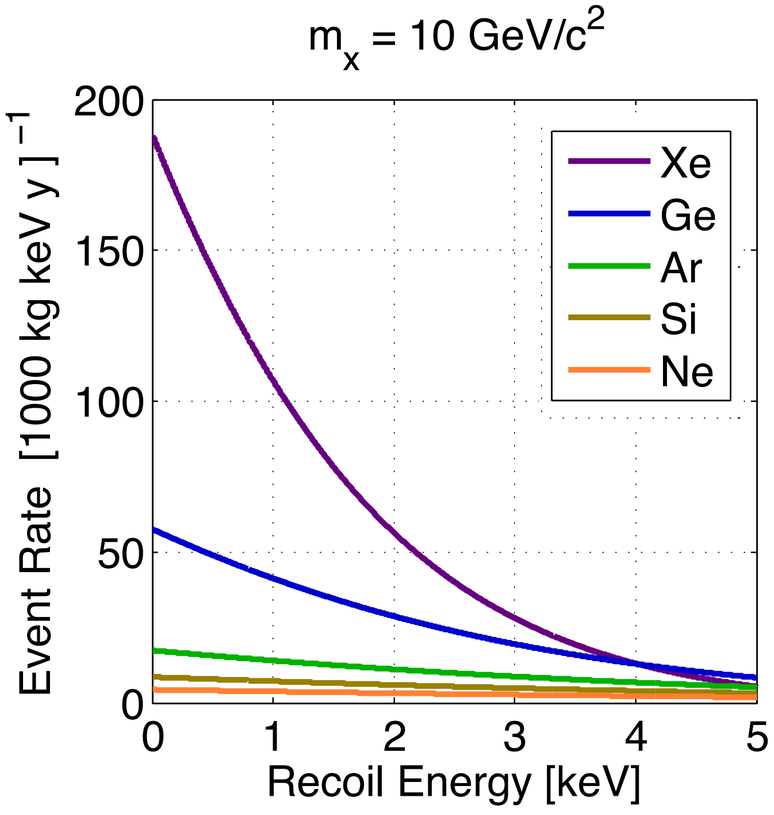
Status of the LUX and LZ programs

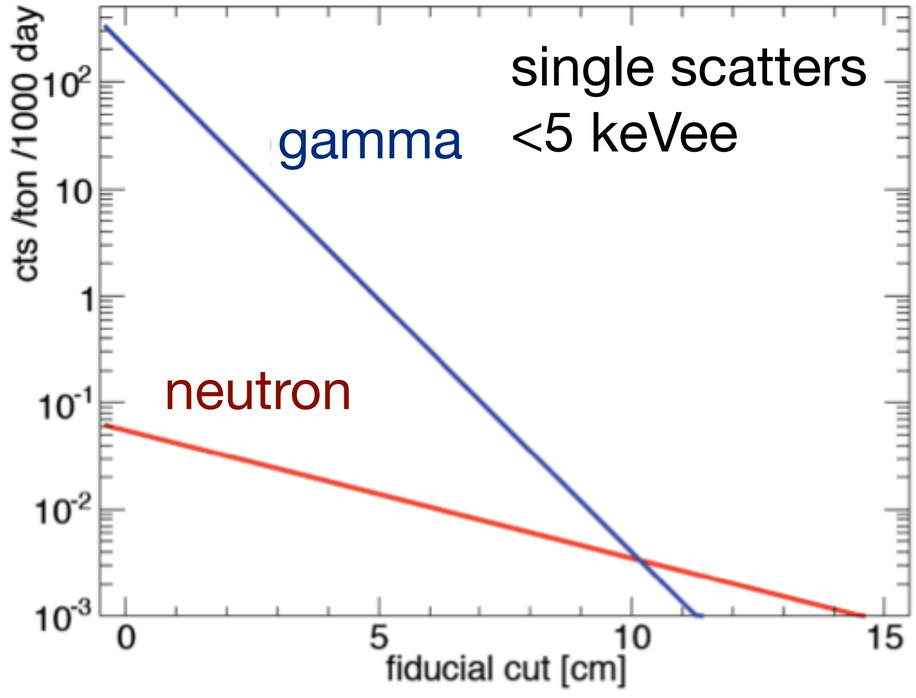
Berkeley Workshop on
Dark Matter Detection
June 8, 2015
Scott Hertel (Yale)

Liquid Xenon

enhanced coherent
nuclear scattering (~A^2 μ^2)

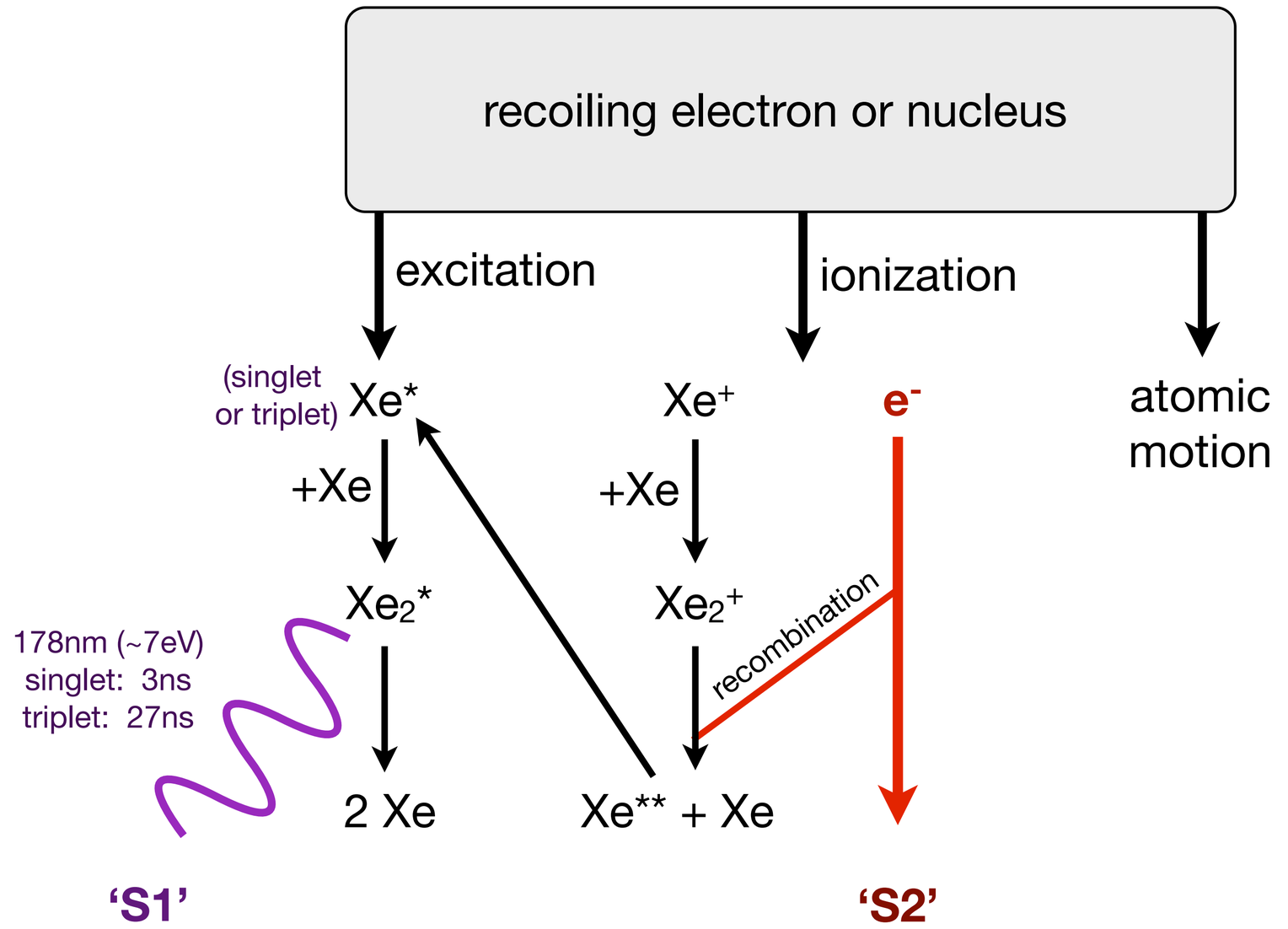


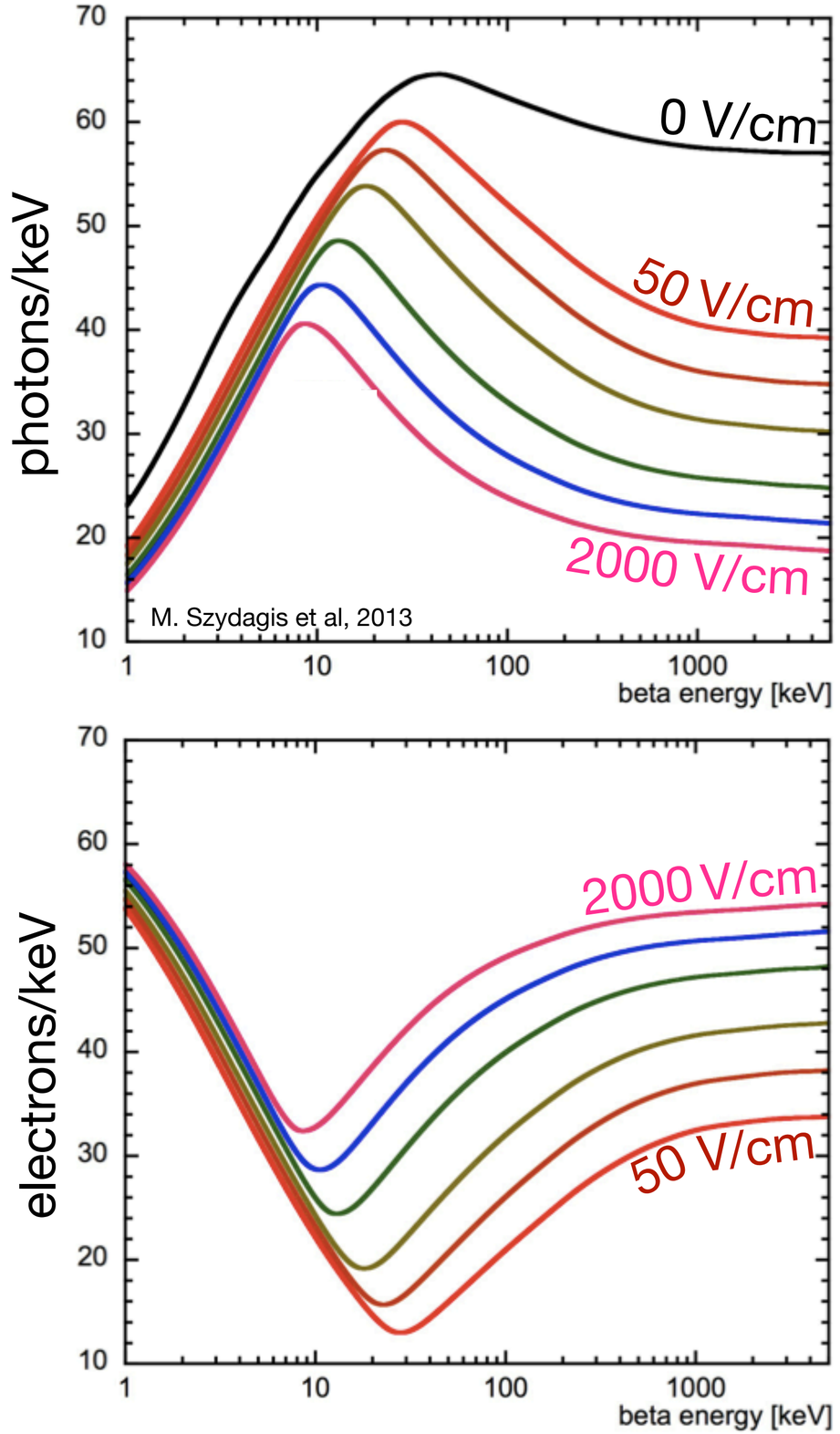
self-shielded
external backgrounds



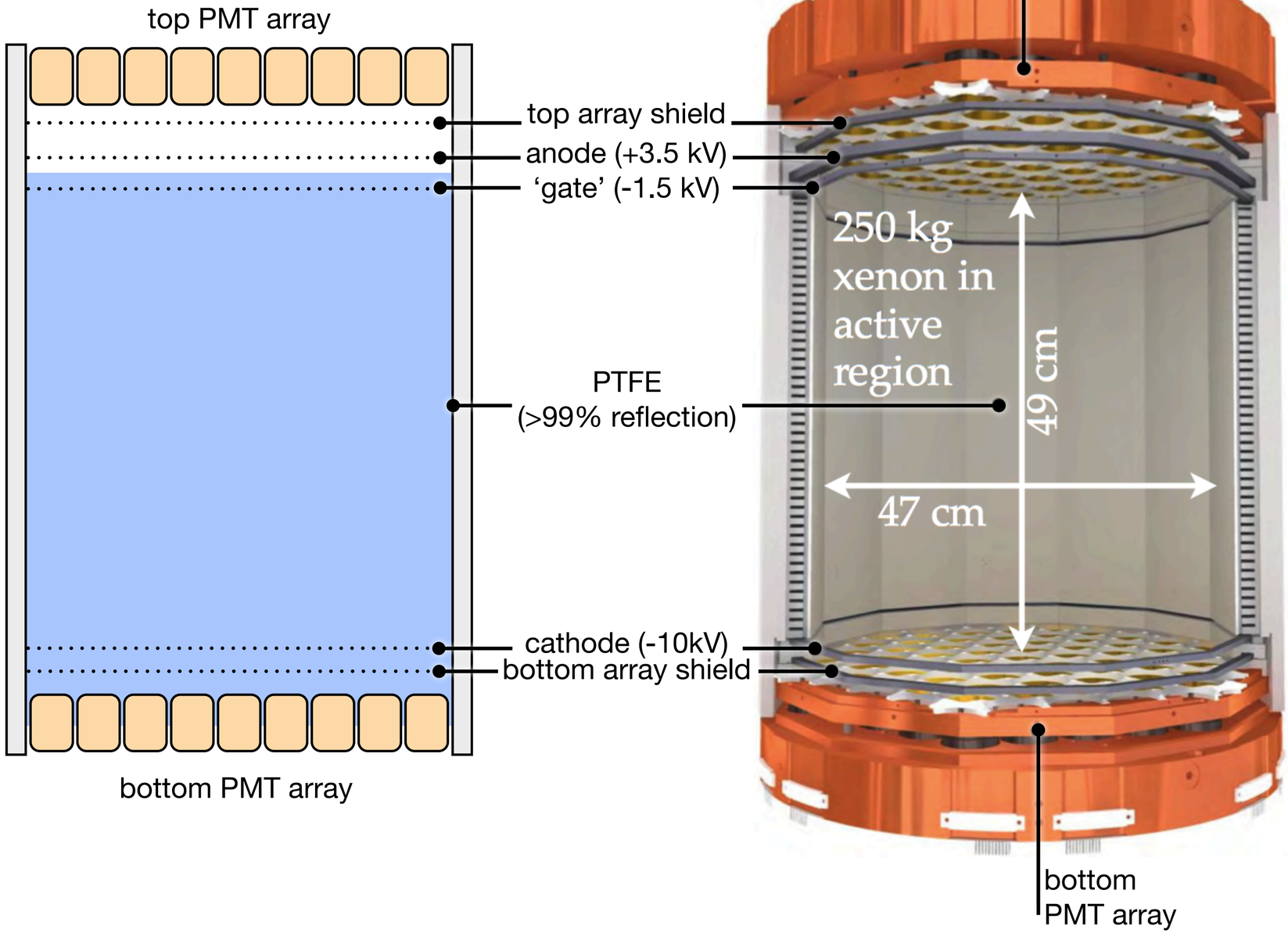
+ few-keV threshold
+ ER/NR discrimination

two intertwined signals: light and charge

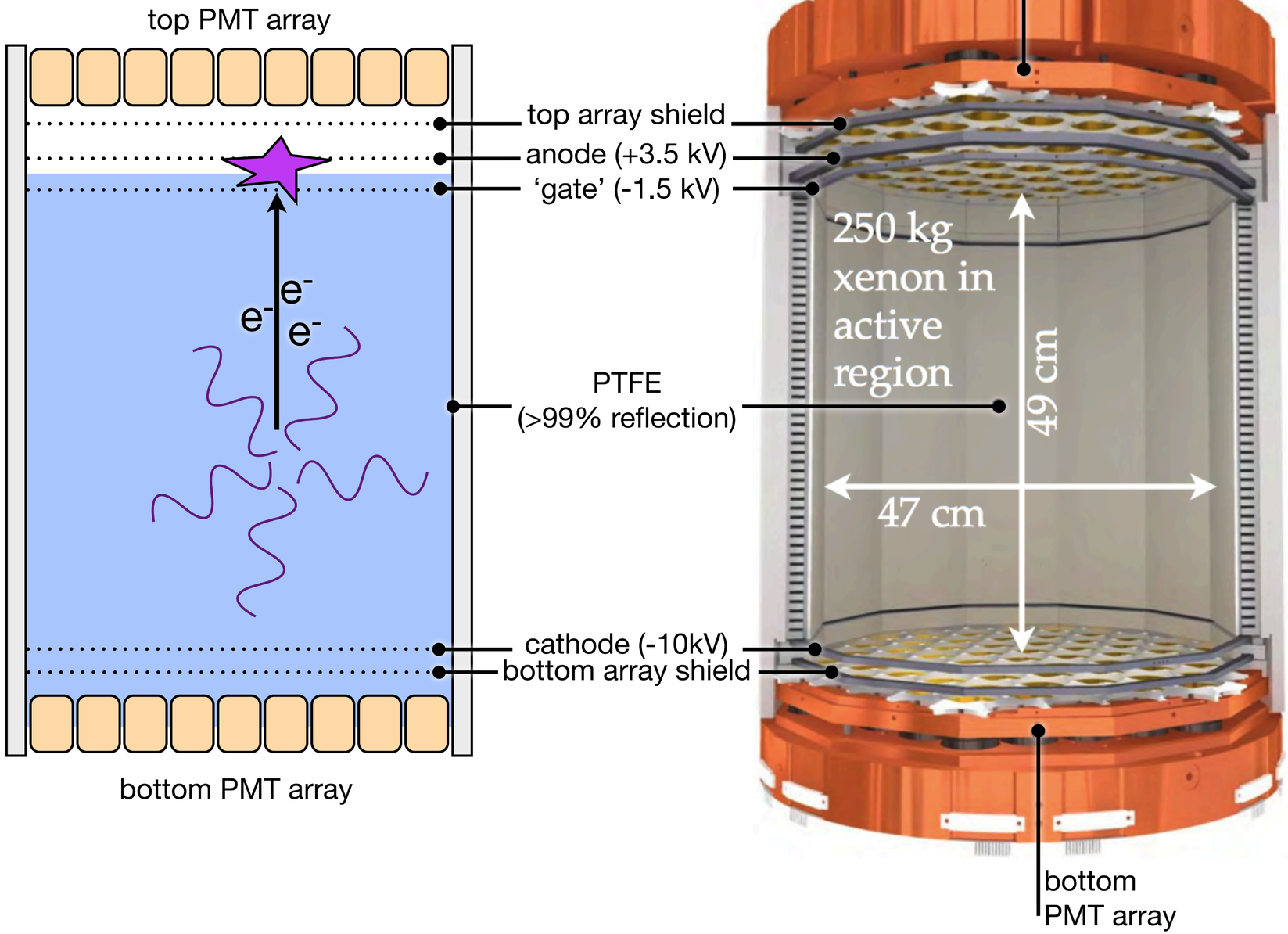




LUX Time Projection Chamber



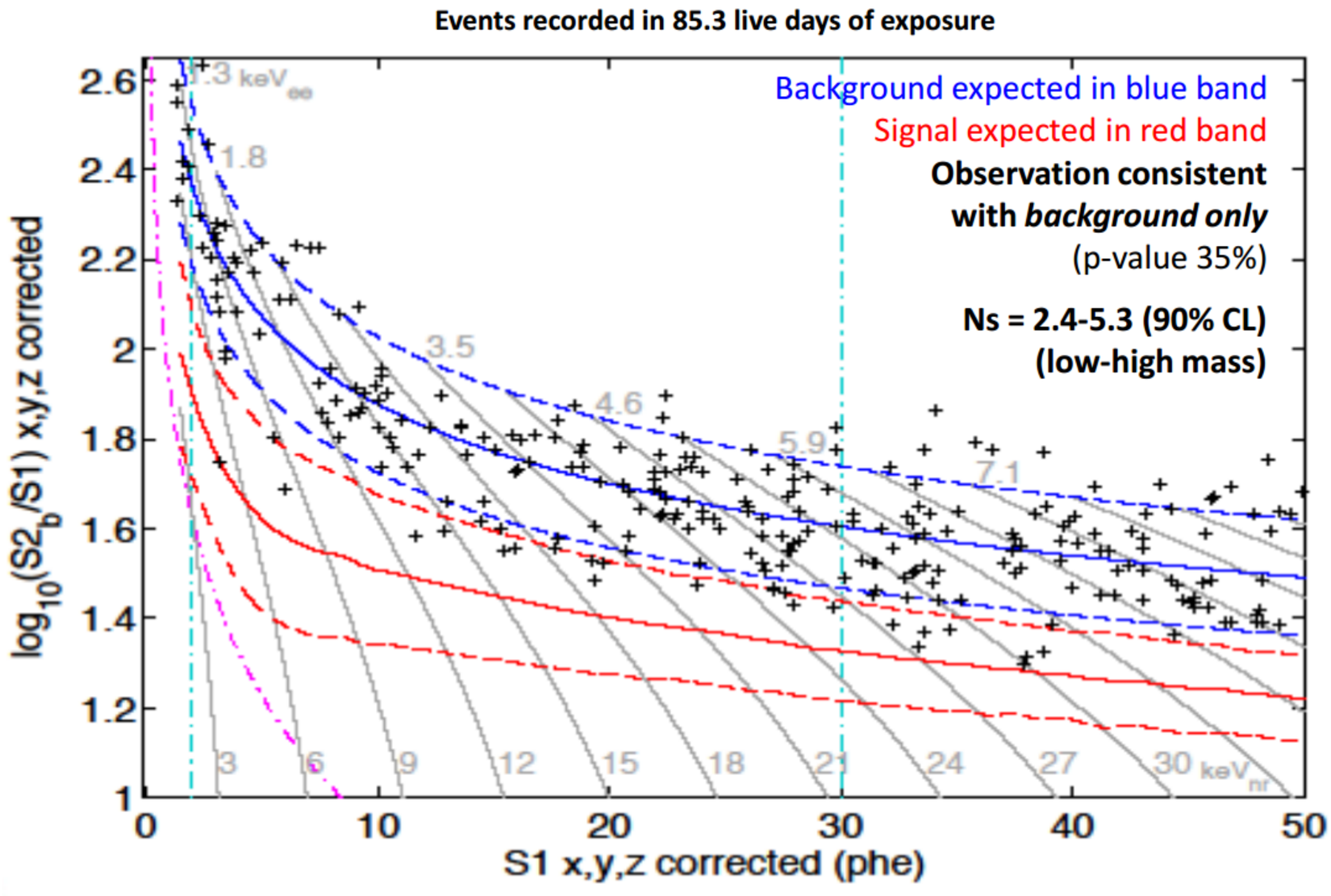
LUX Time Projection Chamber



Initial 85.3 live-day Exposure

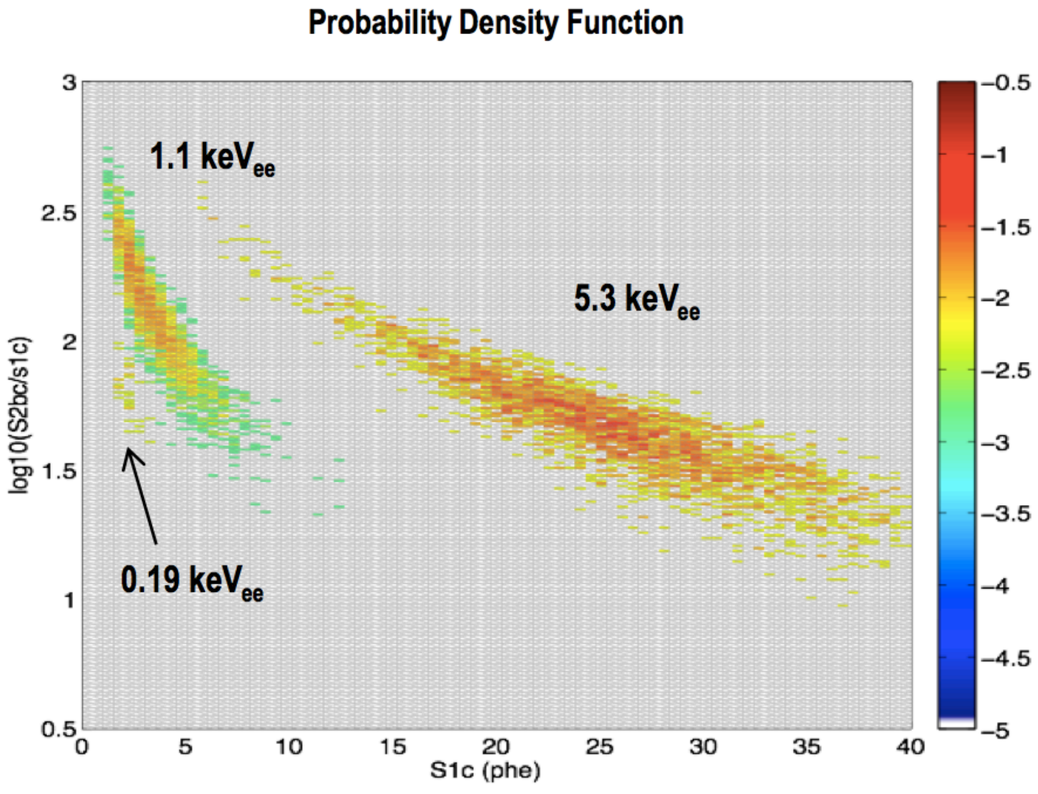
radius<18cm:
3.1±0.2 mdru

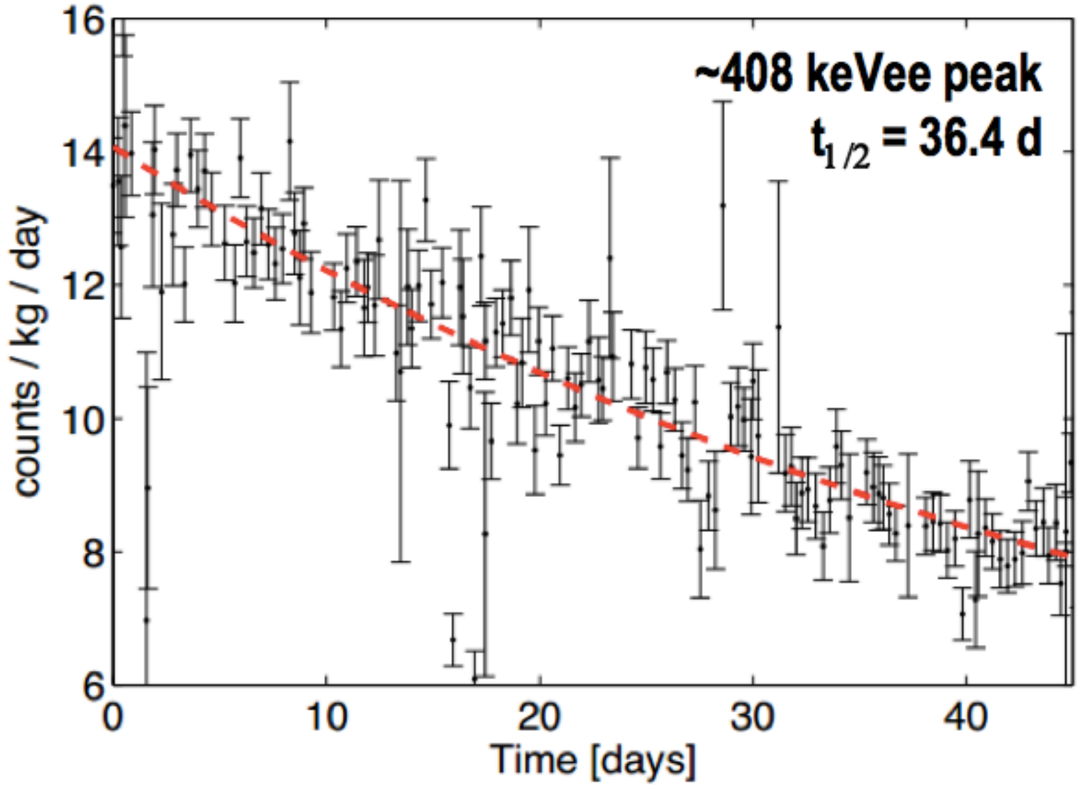
Xe127 at 1 and 5 keVee
($t_{1/2}$=36d)



Xe127

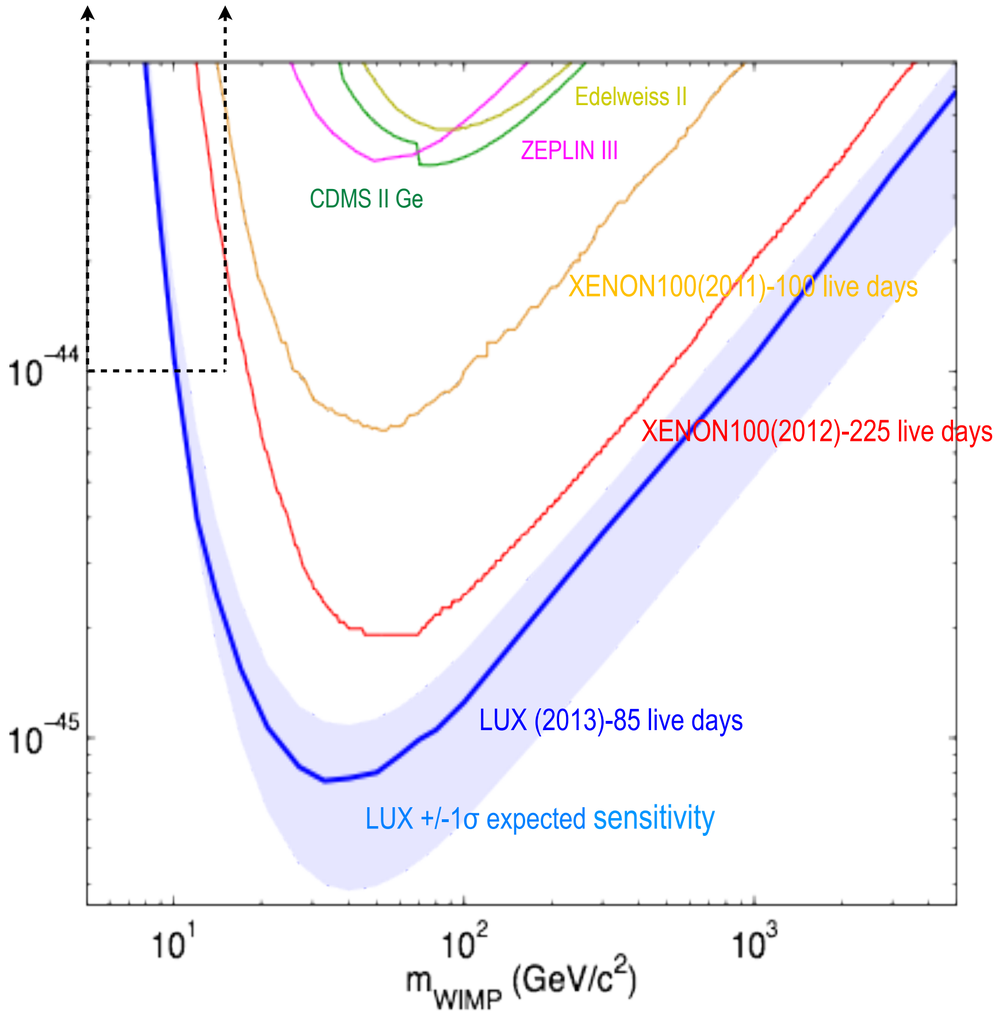
Electron capture gammas at 203 or 375 keV (possibly escaping the TPC)
x-ray / auger emission corresponding to ^{127}I : 33.2, 5.3, 1.1, 0.19 keV

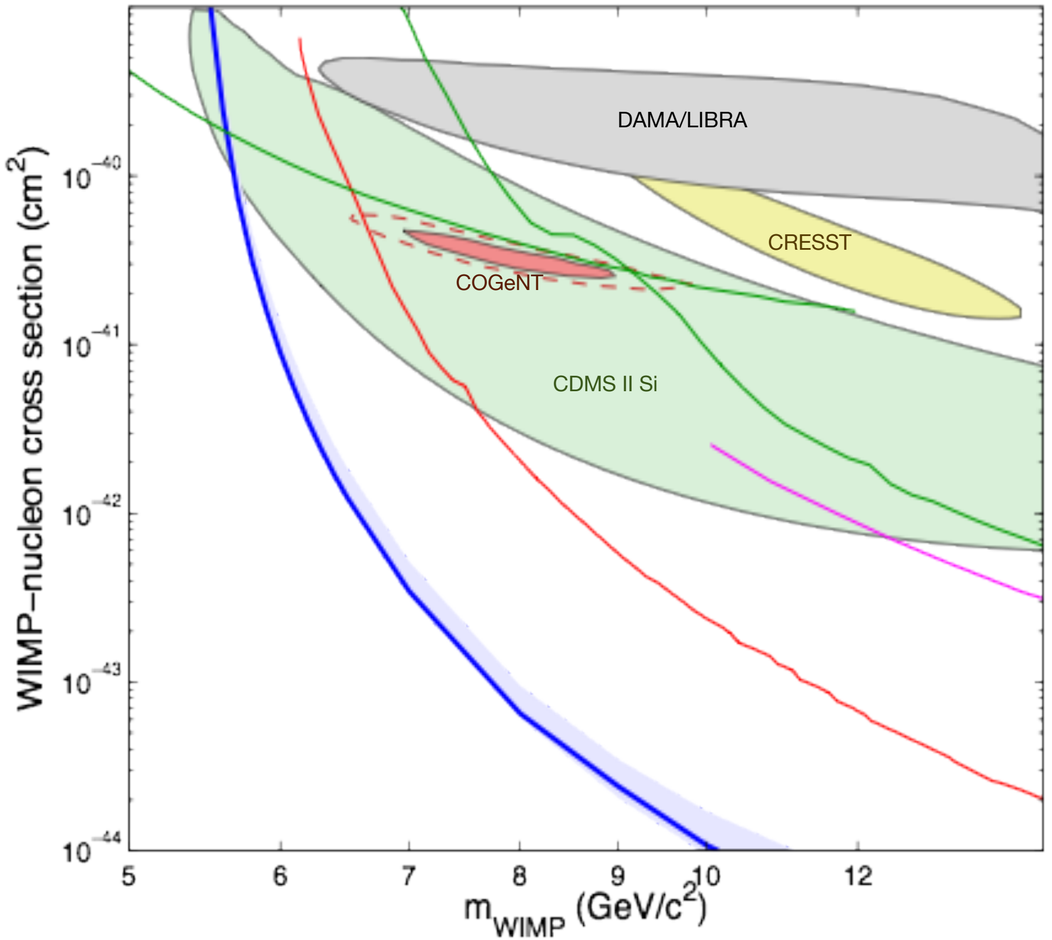




The 2013 limit

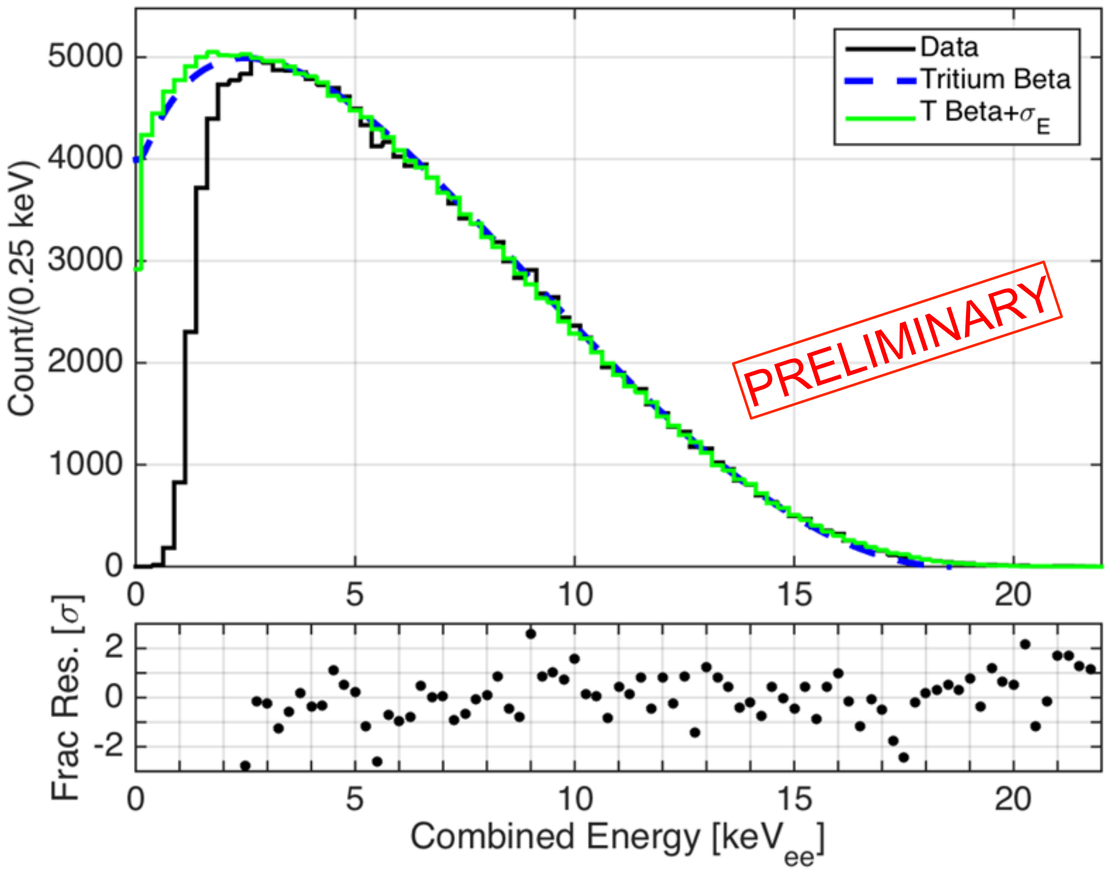
(apologies your curve is not on here!)

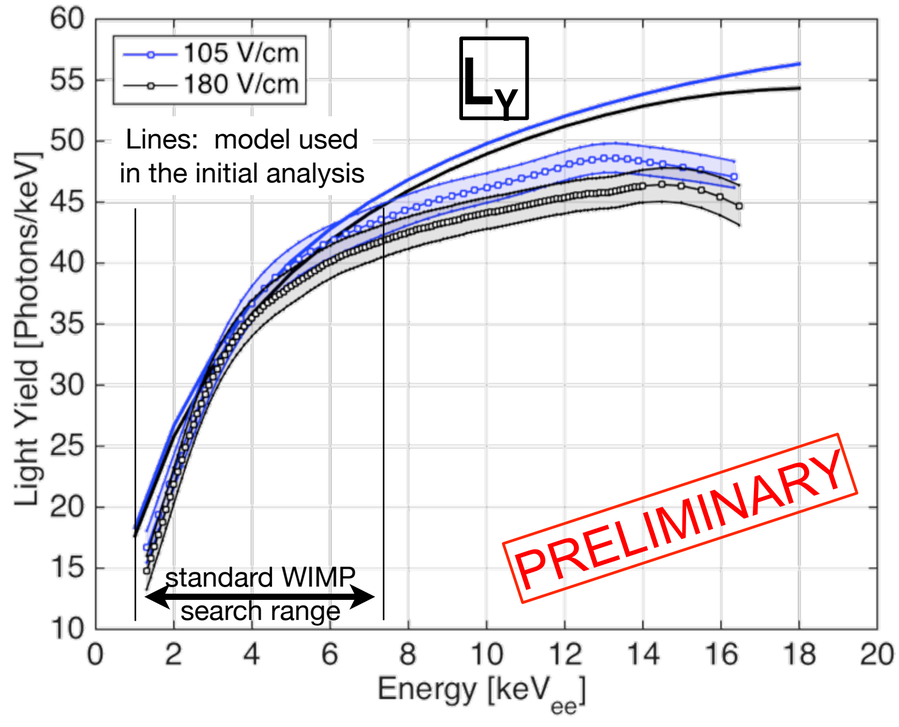


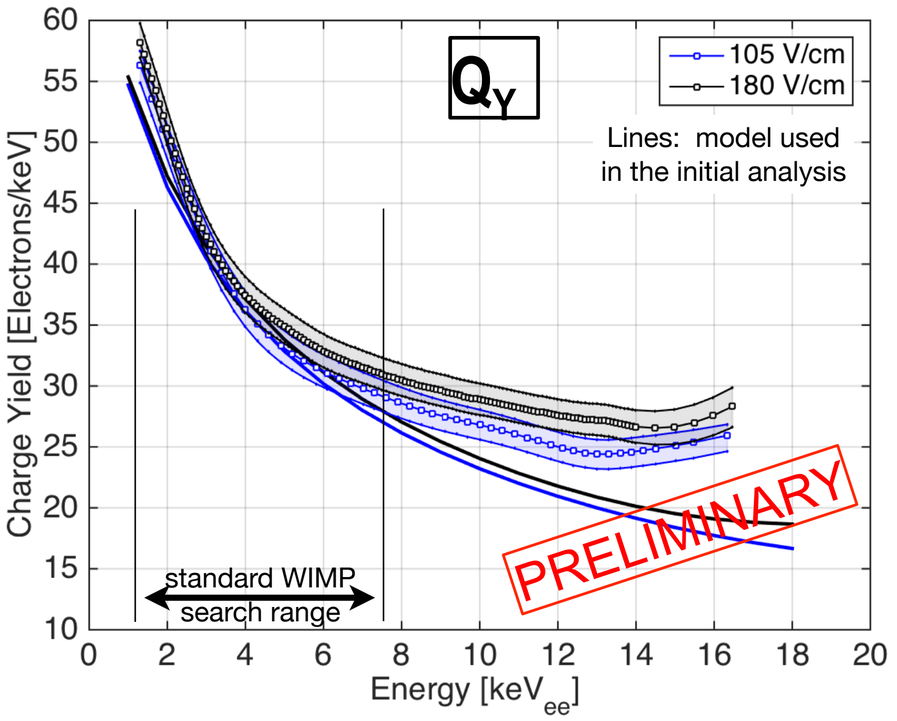


Improvement 1a:
ER calibration (CH_3T)

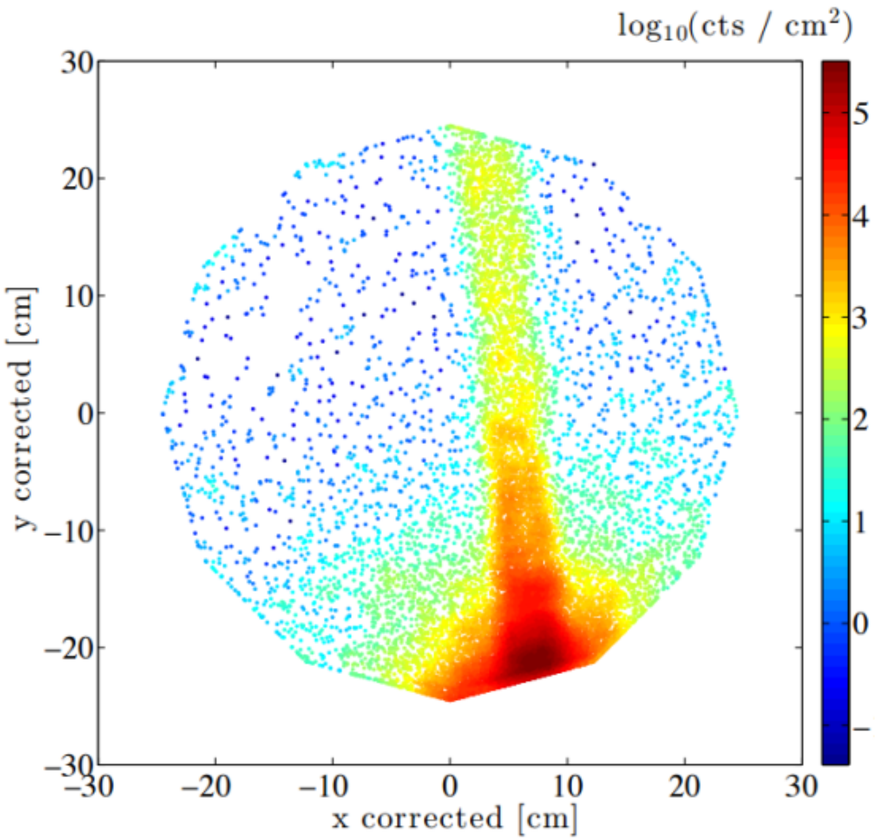
ER Qy and Ly down to ~1keVee



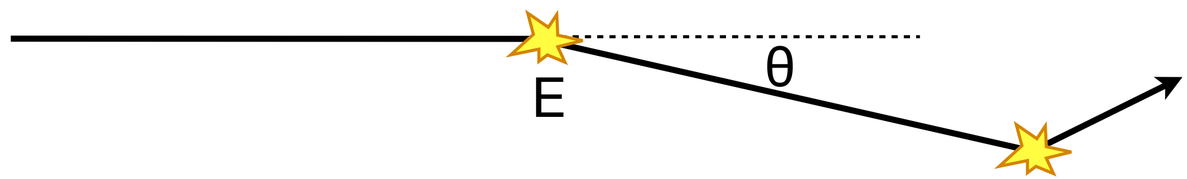




Improvement 1b:
NR calibration (DD)



high-energy penetrating neutrons (2.45MeV)



Double-scatters: 1 S1 + 2 S2
first scatter E well-constrained
combine first E and first S2: Qy(E)

Then, apply E(S2) to single scatters to derive Ly(E)

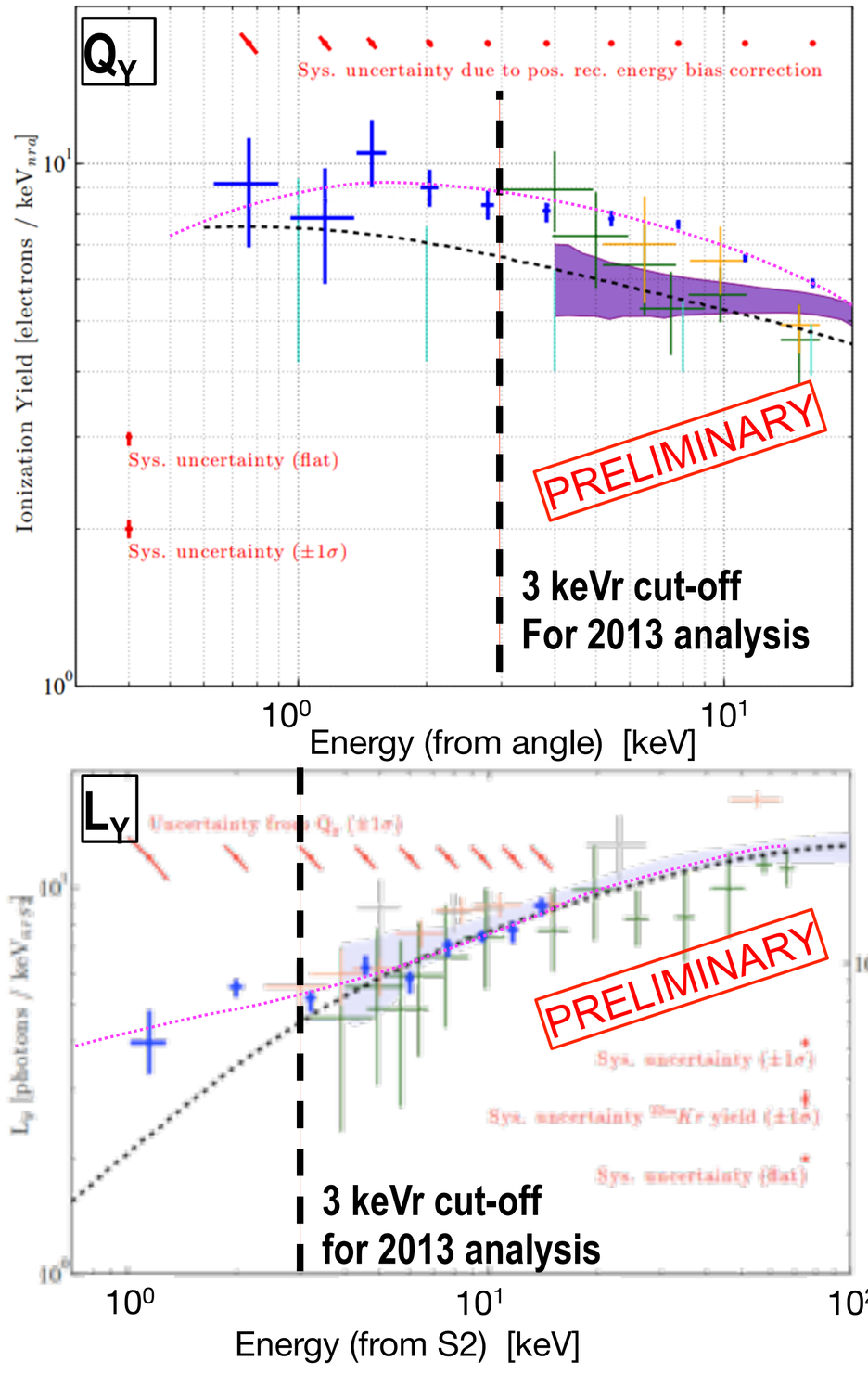
Improvement 1b:
NR calibration (DD)

DD first shown in Feb 2014 with very preliminary analysis, significant progress since then, with dedicated paper in preparation.

Qy measured down to 0.8 keVr
Ly measured down to 1.2 keVr

initial run3 result, not based on LUX data

LUX DD-based, upcoming run3 result
(not showing included uncertainty)



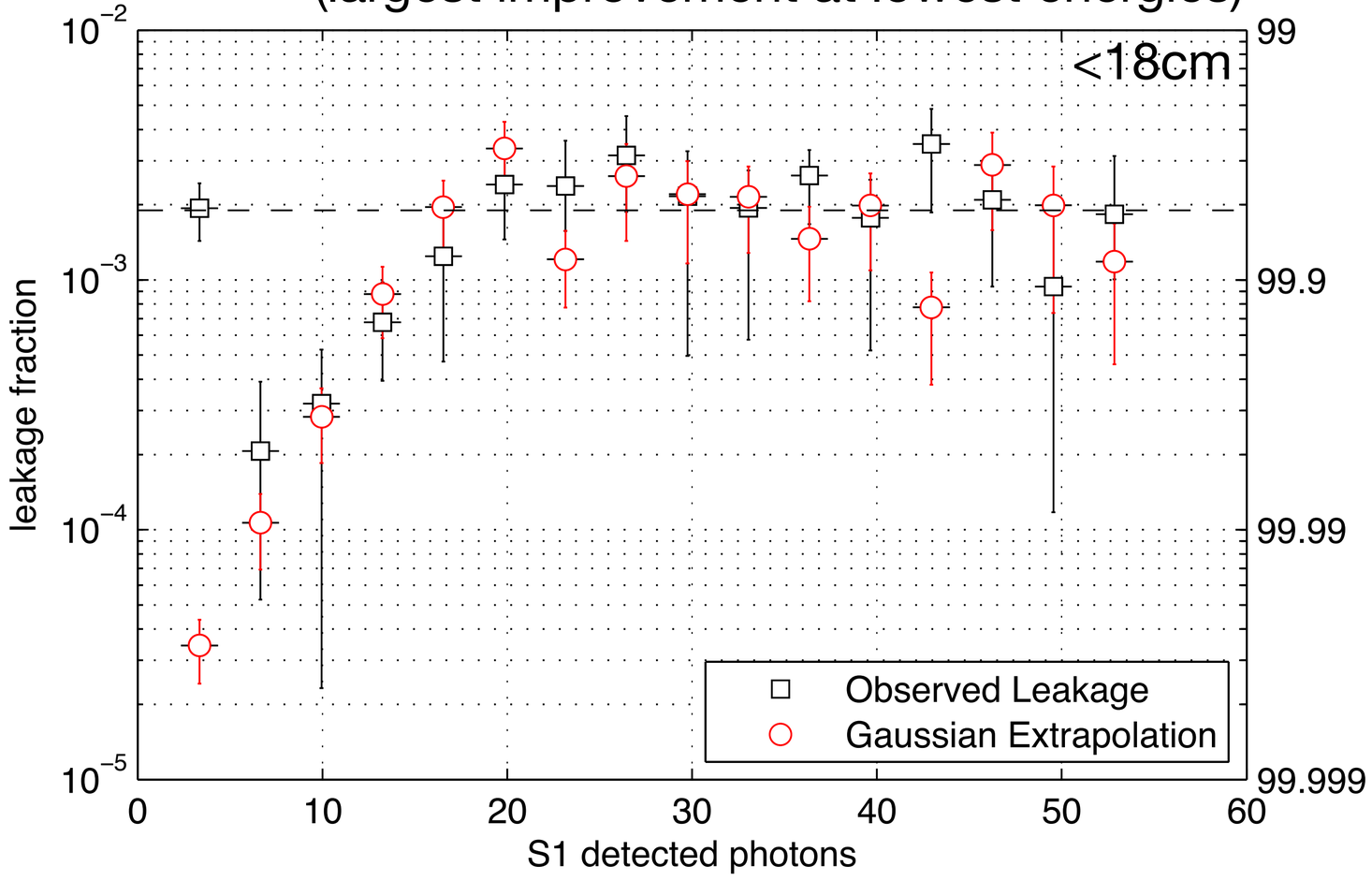
Improvement 2: better analysis algorithms (reduced threshold & improved discrimination)

a couple specific improvements:

better baseline subtraction

S1 photon number estimate (rather than pmt pulse area)

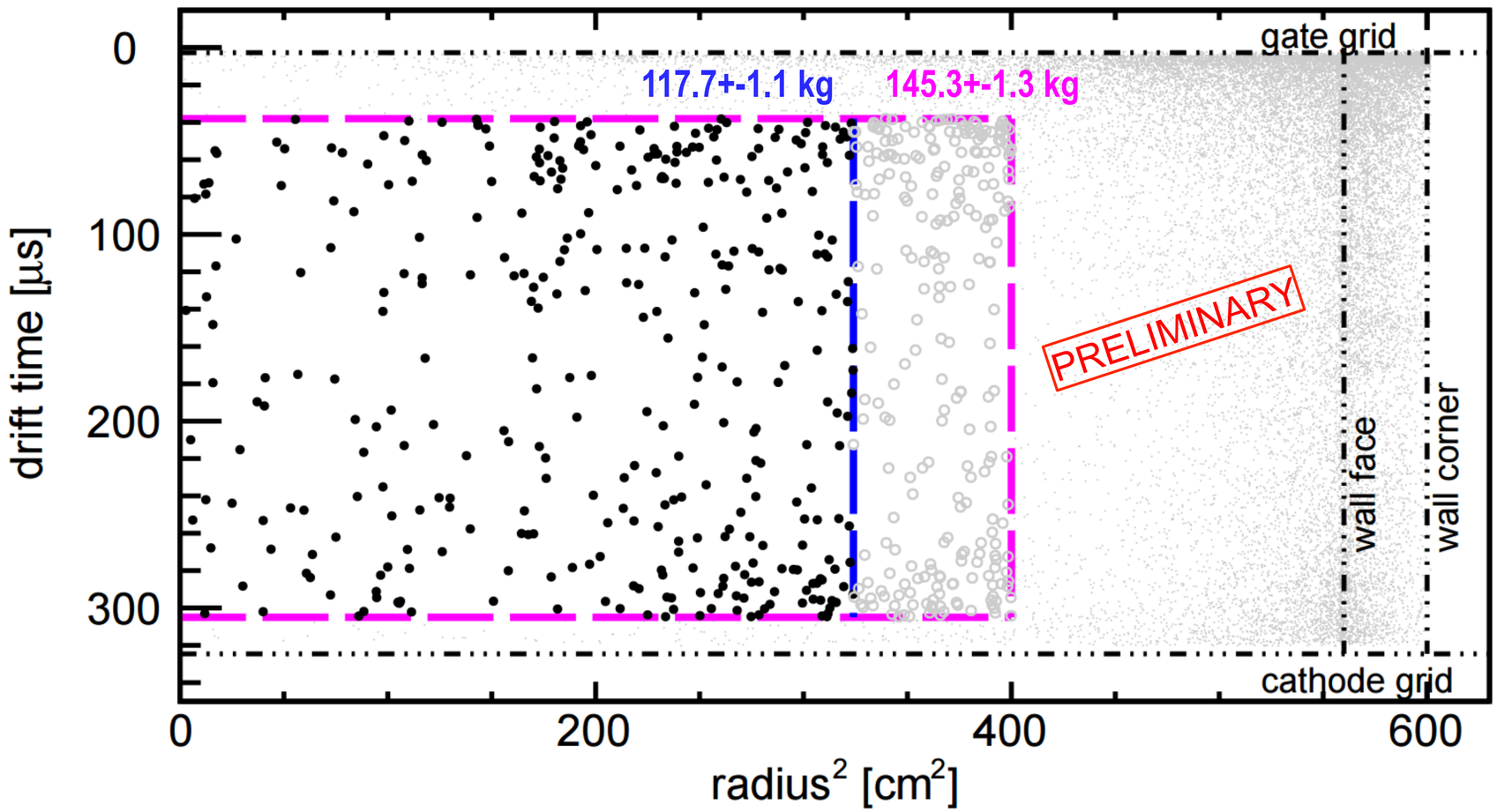
original run 3: 4e-3
new run 3: 1.9e-3
(largest improvement at lowest energies)



Improvement 3: better understanding of high-radius low-S2 backgrounds

some improvements in xy position reconstruction
empirical Pb210 model folded into profile likelihood

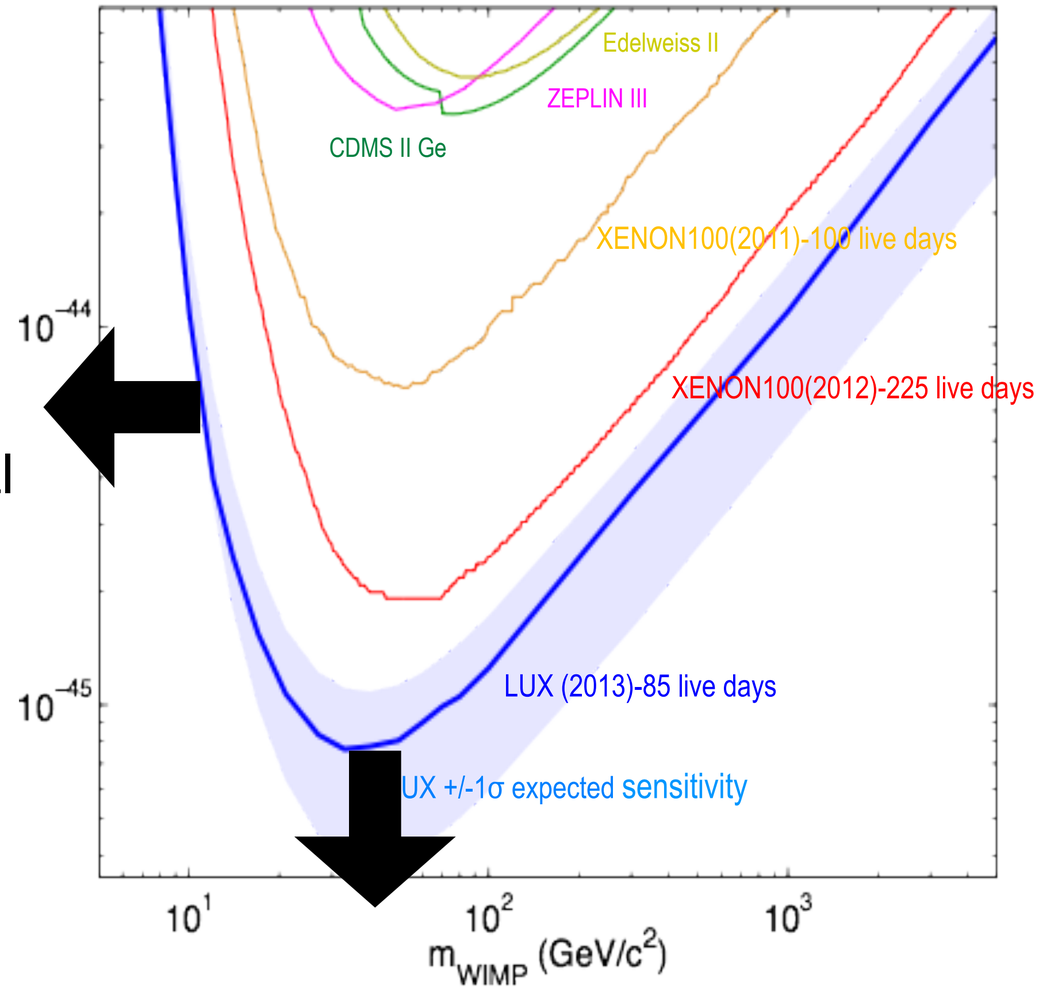
-> fiducial volume extends to higher radii



improved sensitivity paper “next few weeks”

threshold

non-zero S1 signal
down to 1.2 keVr
(from 3keVr)



threshold
+ discrimination
+ fiducial volume

ongoing LUX operations

Run 3

Middle of 2013: background running
End of 2013: post-exposure high-stats CH3T and DD calibrations

Grid conditioning

Main accomplishment: extraction field higher by %17.

Run 4

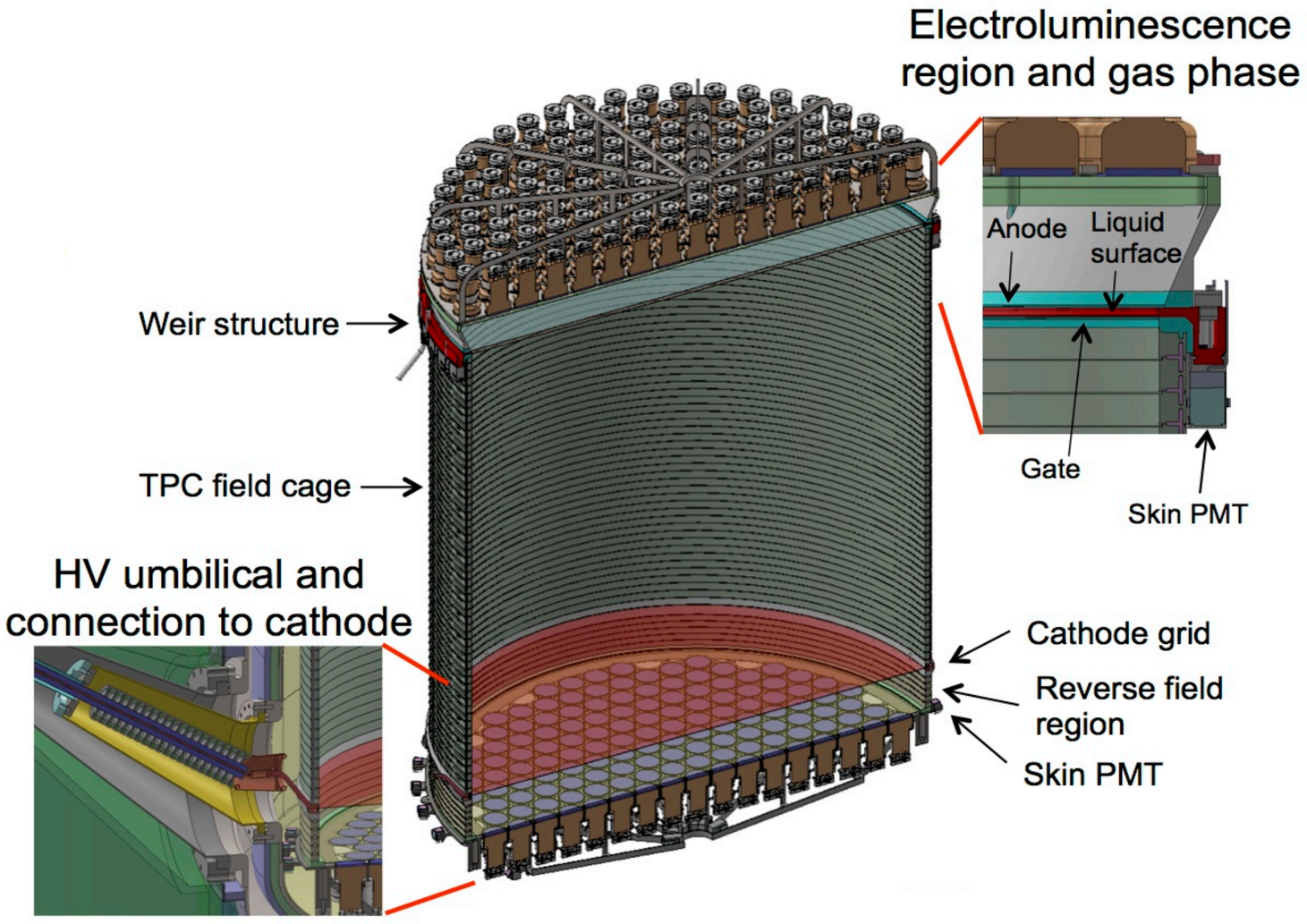
Started September 2014 with new grid voltages
New round of high-stats calibrations (four weeks of DD!)
Recurring DD + CH3T calibrations (second round in March-April)
Aiming for ~300 live-days of background exposure (~100 so far)
(remember: near-zero Xe127 rate)

LZ

x50 in fiducial mass

10 T xenon mass
7 T active
5.6 T fiducial

The LZ TPC



benefits of scale

linear scaling of WIMP rate

exponential improvement of self-shielding

design challenges of scale

larger voltages for the same field/discrimination

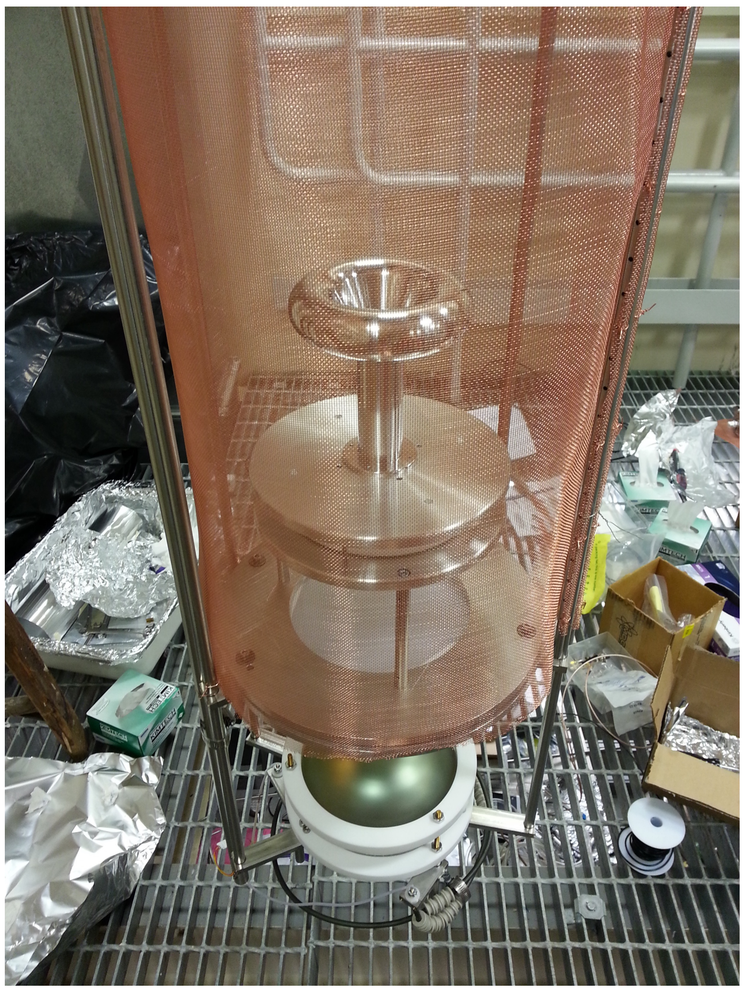
require improved photon collection for the same threshold

Designing and testing for 200kV in LXe

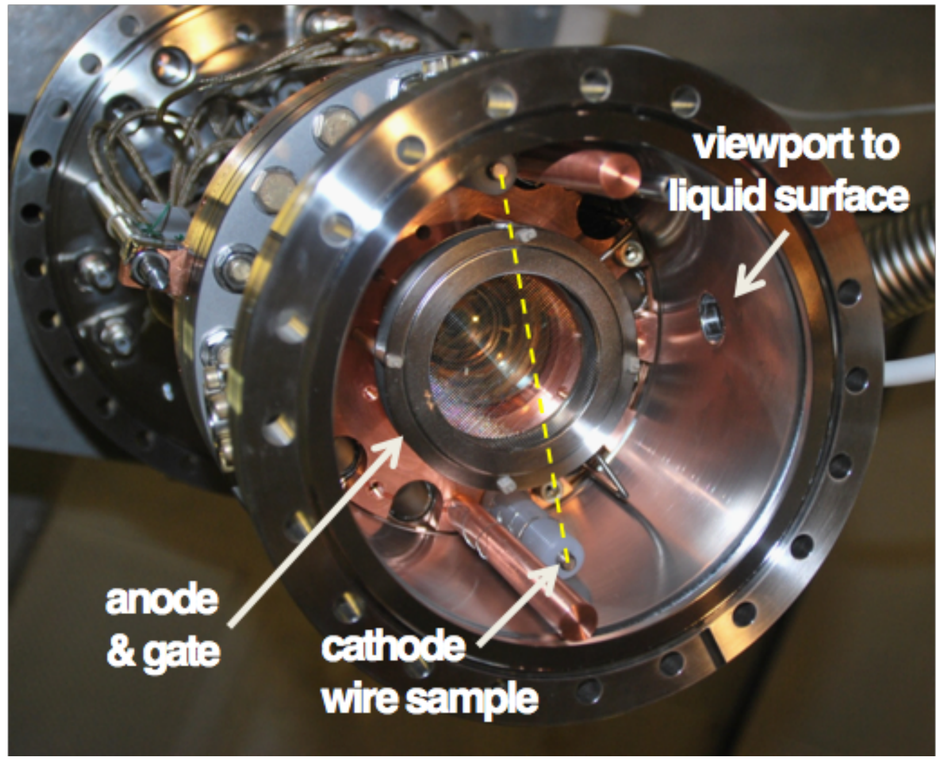
100kV baseline: ~700 V/cm
(LUX run3: ~180 V/cm)

feedthrough

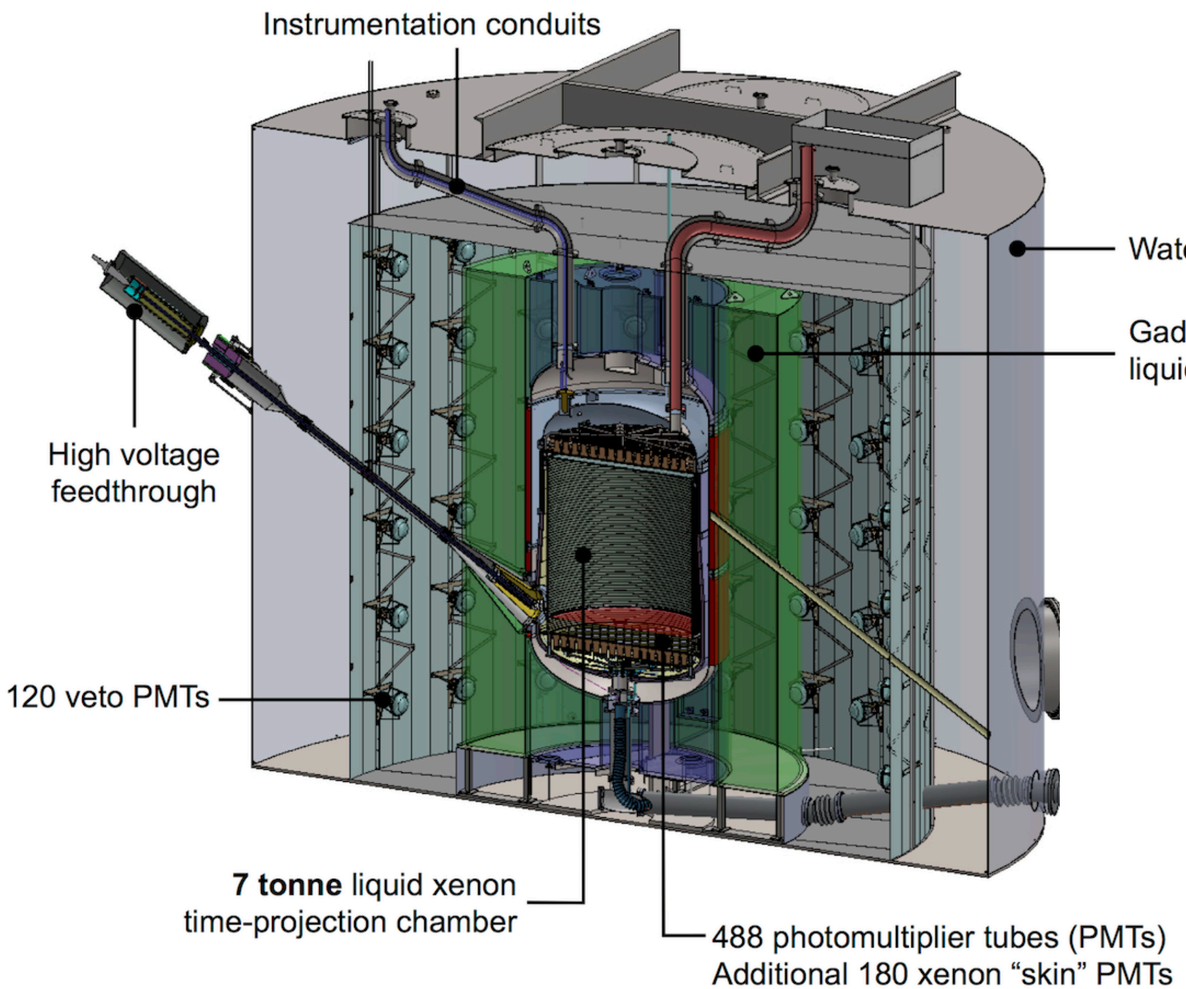
highest-field region of TPC



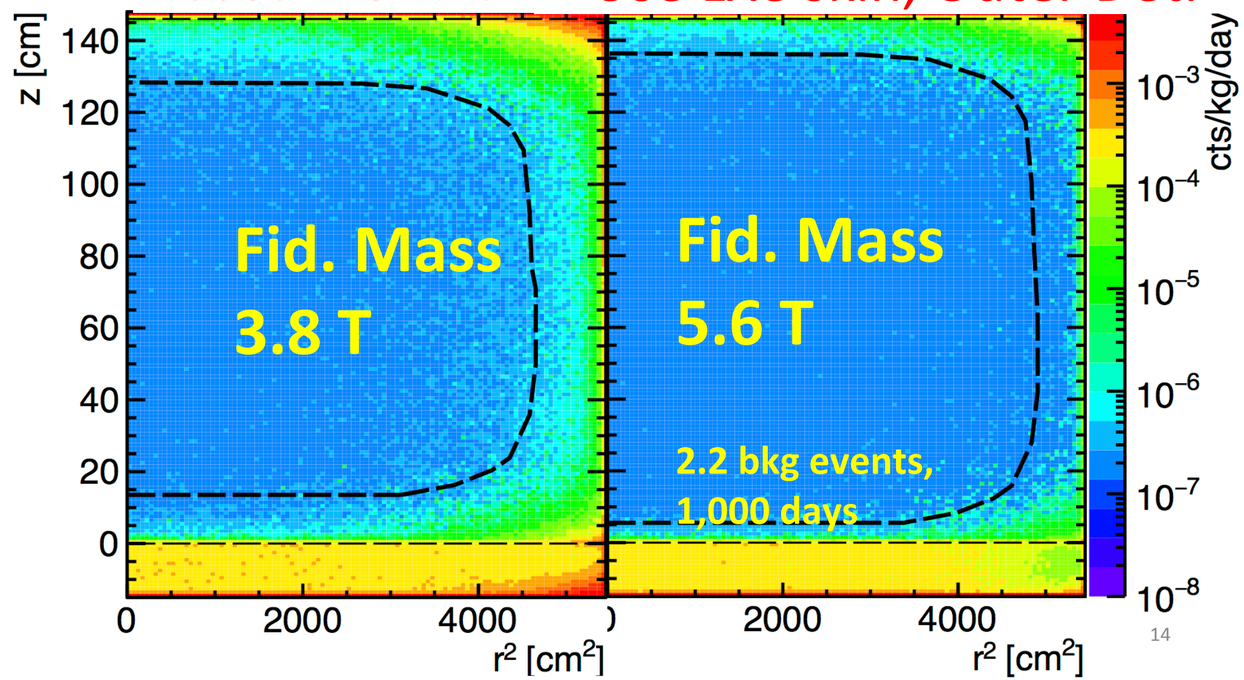
grid wire light emission studies



Background rejection outside the TPC



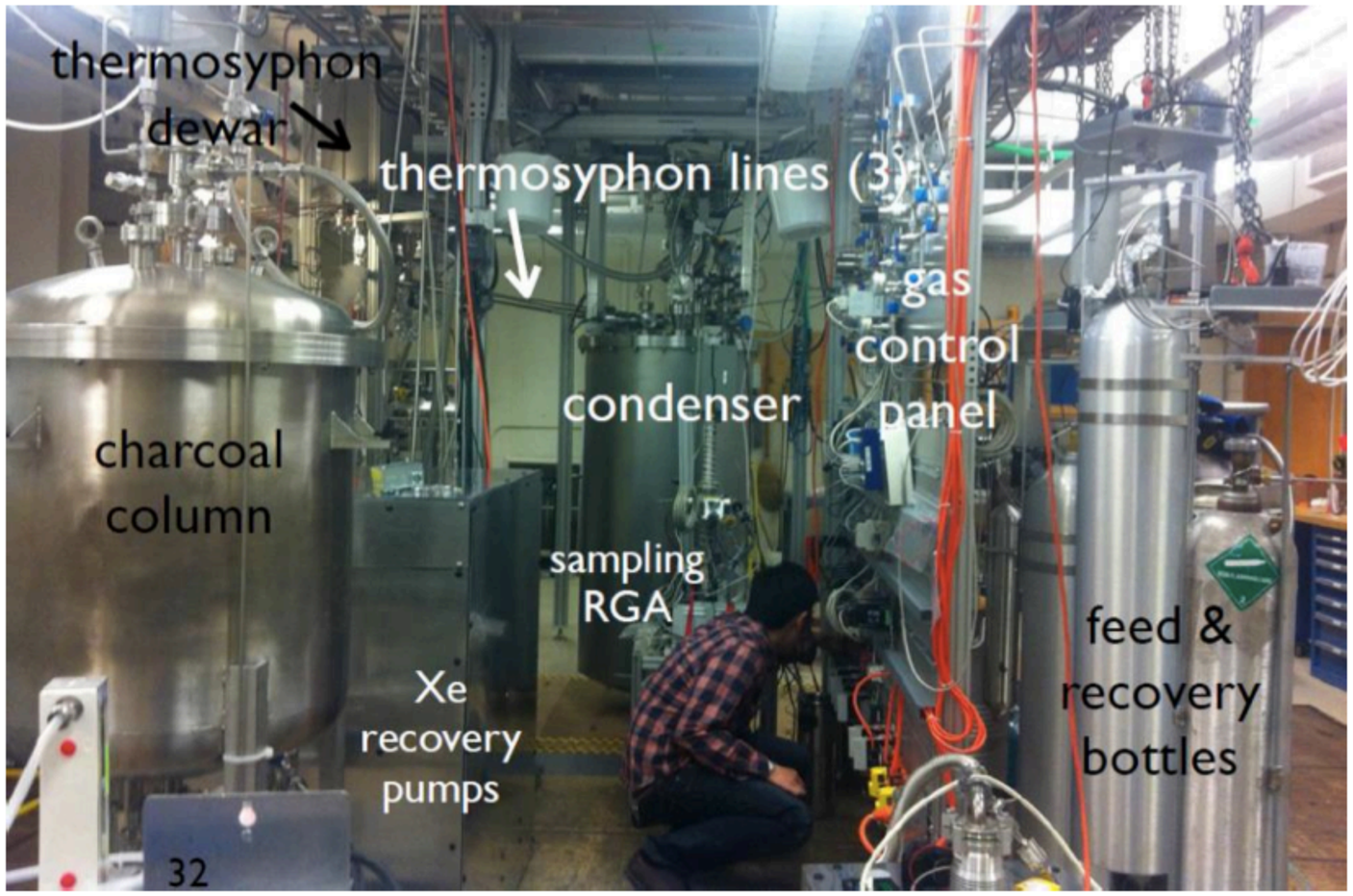
TPC	488 PMTs
LXe ‘skin‘	180 PMTs
Gd-loaded scintillator	120 PMTs
water	(same 120)



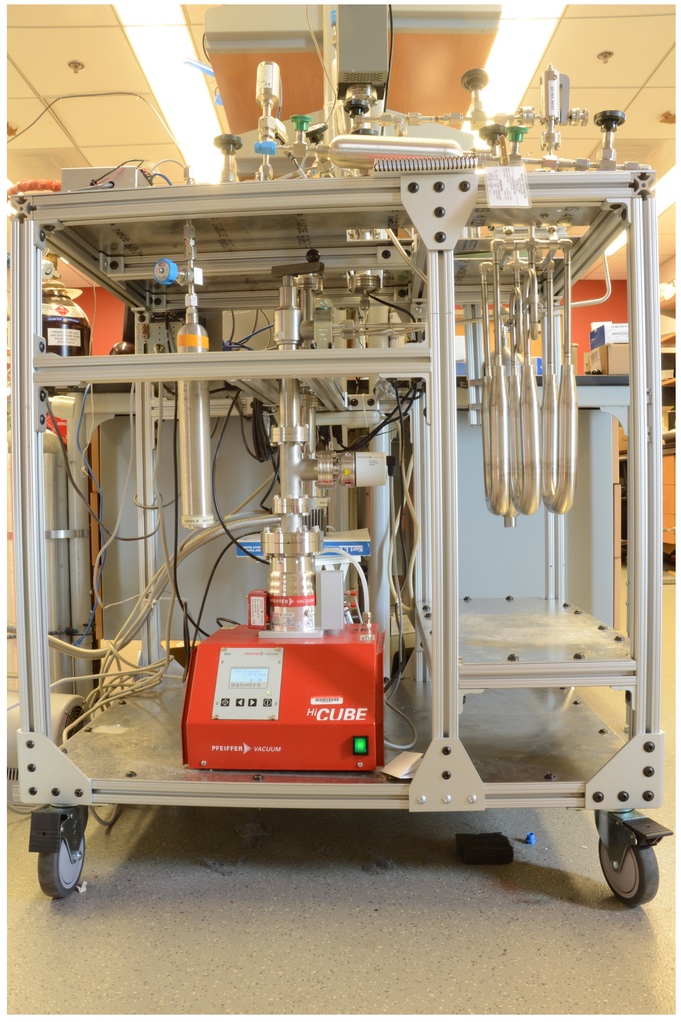
Kr85

LUX average: 4 ppt
Best LUX batch: 200 ppq
LZ Goal: <15 ppq (<10% of neutrino background)

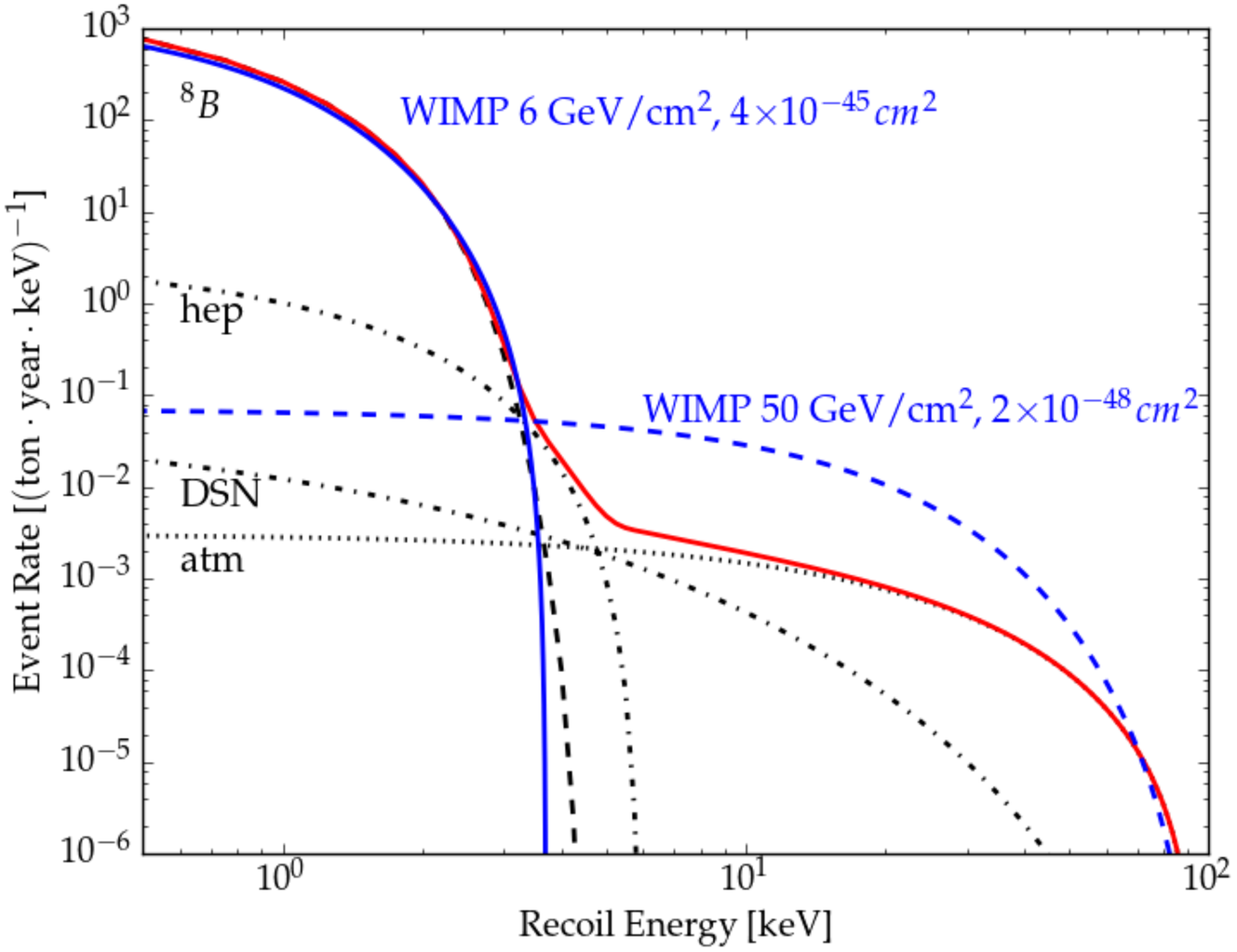
SLAC is setting up to improve both purity and throughput (200 kg/day)



U. Maryland is improving the sampling system (measuring ppq is hard)



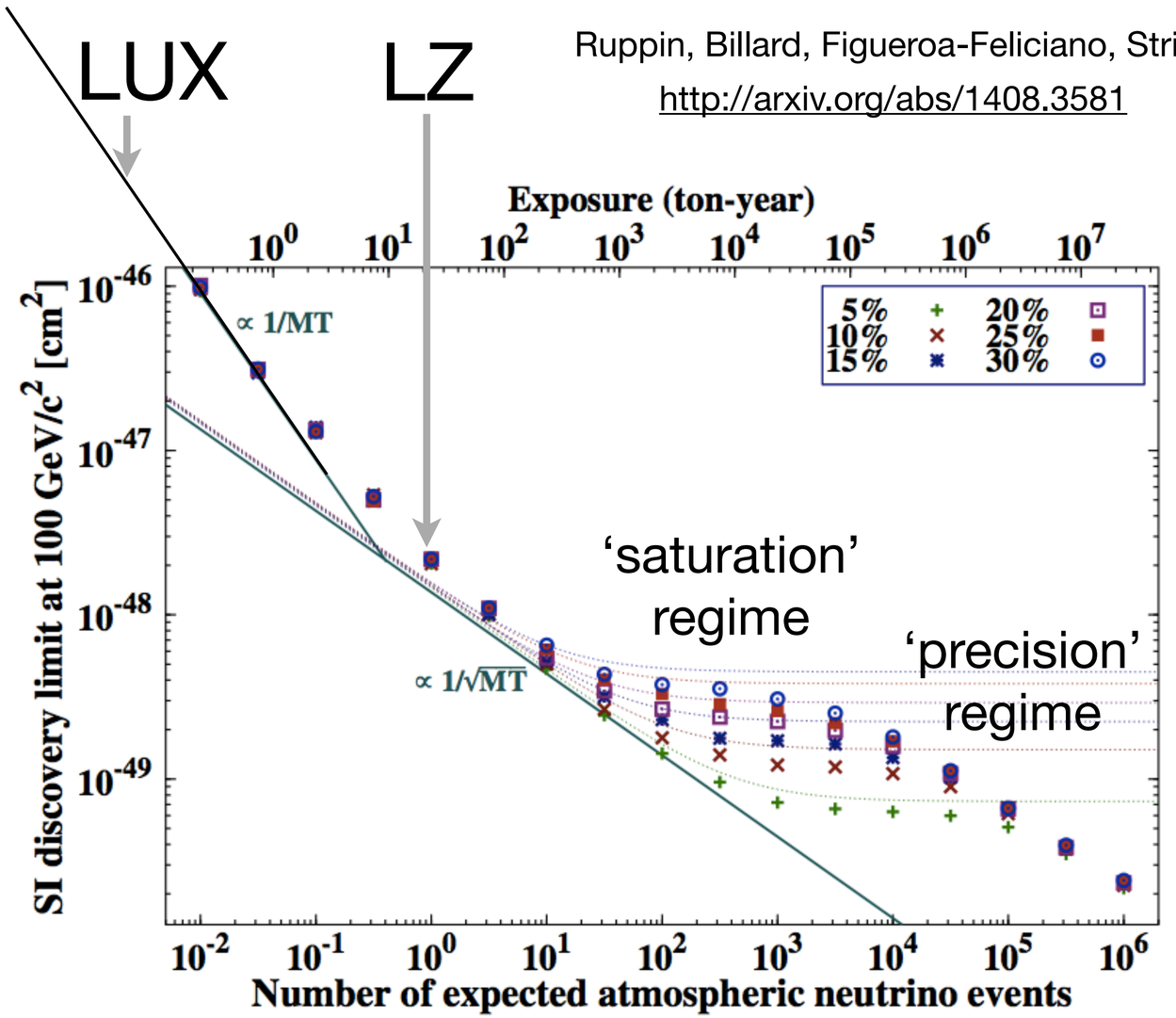
Newly dominant: solar coherent neutrino scattering



expectation after 1000 days:

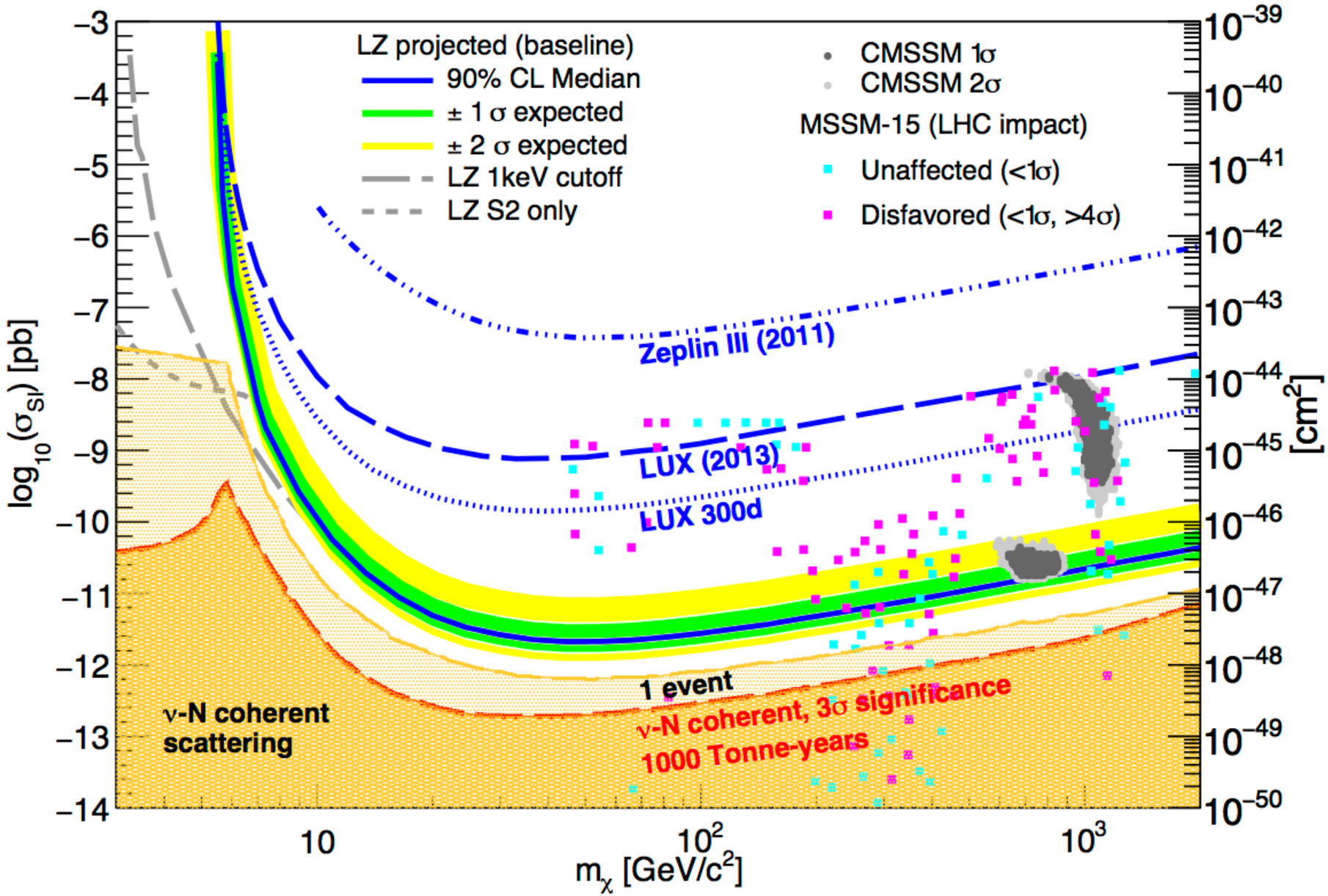
~10 ^{8}B events (depending on threshold)
~0.5 other

Newly dominant: solar coherent neutrino scattering



Ruppin, Billard, Figueroa-Feliciano, Strigari
http://arxiv.org/abs/1408.3581

1000-day projection



LZ timeline

2012
March LZ collaboration formed
May First collaboration meeting
September DOE CD-0 for G2 dark matter experiments

2013
November LZ R&D report submitted

2014
July LZ Project selected in US and UK

2015
April DOE CD-1/3a approval, similar in UK
now procuring Xenon, PMTs, cryostat

2016
April DOE CD-2/3b approval, baseline, all fab starts

2017
June Begin preparations for surface assembly at SURF

2018
July Begin underground installation

2019
Feb Begin commissioning & running